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**Lexical stock under scrutiny: exploring the  
mental representations of morphologically  
complex structures**

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## **OŚWIADCZENIE**

**Ja, niżej podpisany**

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## **Introduction**

The following paper is devoted to the exploration of morphological relations between mental representations of words and their textual realisations. The ability to read written texts has accompanied humans for about six thousand years as opposed to the spoken language which is said to be the more natural mean of communication with a history of about six million years. Both ways of communication have appreciated a long standing tradition, however psycholinguistic research delving into the former phenomenon seems not to have been sufficient to uncover most of its peculiarities. This paper deals with the phenomenon of visual word recognition yet by no means is it thought to exhaust the subject. It has been divided into the following three parts.

The first chapter deals mainly with the theoretical approaches to the way humans are able to recognise written texts. Various plausible processes operating at the level of meaning retrieval from the written text are presented. Moreover, factors determining the speed and quality of word recognition are briefly expanded upon. The subsequent part of the present work attempts to provide a concise account of the dominating models of visual word recognition both those which incorporate the role of morphology and those which do not. Additionally, the evolution together with the most recent formulation of the idea of the mental lexicon is explicated.

The ultimate part of the paper concentrates on the empirical study which was carried out for the purpose of this thesis. It was modelled on (Pilon 1998) and aimed at verifying the pseudoprefixation hypothesis. The benefit of having a model experiment is that the results of the two studies can be contrasted thus lifting the veil of secrecy on the role of morphology in visual word recognition. The assumption put forward is that if the phenomenon of pseudoprefixation exists the role of morphology in visual word recognition should be acknowledged.

# **Chapter One: A selective overview of the visual word recognition research literature**

## **1.1. Introduction**

This chapter is devoted to a brief discussion of the literature of visual word recognition and is divided into two main parts: one concerning sublexical stages of word analysis and the other concerning the analysis of the meaning of lexical items. The main focus however, is shifted to the former giving a short account of various theories related to written text recognition whose formulation immensely contributed to the understanding of word perception. The data is presented predominantly from the diachronic perspective to show the rapid development of this branch of science.

## **1.2. Definition, scope and goals of visual word recognition research**

‘Left, right, left right’ - this is the probable yet simplified command (naturally, pushed to the extreme) sent by the human brain to the muscles located in the lower limbs. People in the course of their everyday life are perfectly unaware of numerous immensely complex activities enabling them to function properly. One such activity, which is the main focus of this paper, is the ability to retrieve meaning from written text, i.e. to read.

The main area of concern for visual word recognition science, which is interdisciplinary research<sup>1</sup>, is the quest for specialized mechanisms (located in the brain) responsible for the blistering and effortless comprehension of written texts. It aims at giving an exhaustive account of the process of text recognition and thereby deals with

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<sup>1</sup> Merging psychology and linguistics

any item constituting a written utterance. Researchers interested in this field of science also investigate patients with various reading impairments, such as dyslexia, aspiring to forge one model of visual word recognition accounting for various phenomena involved in the process of reading.

Albeit human beings have been the main focus of this research, some interest has shifted to computers of late. As the recent developments in IT have enabled more advanced queries, computer machines are not only utilized as auxiliary equipment but rather constitute the object of investigation, e.g. testing theories by implementing them on computers (i.e. computer modelling). Ancillary help is provided by eye tracking machines delivering information about the manner in which we ‘absorb’ written text (see 1.4.1. for further discussion); the latest invention is Tobii - an eye tracker which is non-intrusive and therefore best for fulfilling the ecological validity requirement ([www.tobii.com](http://www.tobii.com)) (Cieślicka 2004).

### **1.3. Sublexical level of analysis**

As has been already mentioned, visual word recognition is occupied with numerous as well as diversified elements processed during the activity of reading, starting with letter features and finishing with whole sentences. The first set of linguistic factors that humans are thought to process when reading relates exclusively to the formal properties of written texts. It is believed that before a language user gains the knowledge about the semantics of a word its form has firstly to be analysed. Therefore, such factors as letter features, letters themselves, phonemes and words constitute the primary interest for researchers preoccupied with the sublexical level of analysis of written texts. I aim to briefly present an account of the research carried out in this field.

#### **1.3.1. The mysterious bouma. Is word shape pivotal to word recognition?**

Words were thought to be recognised as wholes rather than as combinations of letters (or any other constituents) (Cattell 1886). ‘Bouma’ is simply an equivalent term for ‘shape’ (it appears in Saenger 1997). An influential psycholinguist who was the first to suggest the whole shape recognition model (and de facto the only one at that time) was

James Cattell (1886). The reformulation of this model was extended to two possibilities. Proponents of the first one suggest that “the information used to recognise a word is the pattern of ascending, descending, and neutral characters” (Larson 2004: 1). The protagonists of the second possibility claim that words are recognised via “the envelope created by the outline of the word” (Larson 2004: 2). Both imply that the recognition of a shape of a whole word is sufficient to retrieve the intended information from it.

Cattell’s hypothesis was verified in several experiments. The results of one of them are known today as the Word Superiority Effect (Reicher 1969, Wheeler 1970). The researcher in question observed that words are recognised faster than letters in isolation. Thus, it might sound reasonable to claim that the word is the basic unit of visual perception. In subsequent experiments researchers (Woodworth 1938, Smith 1969, Fisher 1975, after Larson 2004) presented their subjects with words exclusively, though they were divided into two groups. The first one comprised items written in lowercase and the second one in uppercase. They found that the process of reading texts written in uppercase is more time consuming than reading the same passage in lowercase. These findings seemed to be a milestone in the formulation of Cattell’s hypothesis. The results could be accounted for in a fairly simple way - lowercase letters have different shapes as opposed to the uppercase lexical items. The same explanation can be used to trace the outcome of the later experiment. When subjects were asked to proofread a piece of writing it turned out that the number of misspellings detected was greater in the case of lowercase text as opposed to the block letter text. In further research it has been found that misspellings consistent with the word shape<sup>2</sup> were more difficult to point out than the misspellings inconsistent with the word shape<sup>3</sup> e.g. Table 1 depicts the situation where *test* was the target word and (1) and (2) were misspellings consistent and inconsistent with the word shape respectively; error rate is provided next to the examples (Haber and Schindler 1981).

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<sup>2</sup> This type of misspelling contains the same patterns of ascenders, descenders, and neutral characters (Larson, 2004)

<sup>3</sup>Such misspellings change the patterns of ascenders, descenders, and neutral characters (Larson, 2004)

Table 1. The effect of word shape distortion on a word's recognition

Misspelled word	Error rate
(1) Tesf	13%
(2) Tesc	7%

The fourth piece of evidence is the alternating case test. Here again, the words written in lowercase letters (4) were read faster than the set in the alternating case (3).

(3) experiment

(4) eXPeriMenT

The findings confirm the word shape hypothesis as the regular shape of a given word is preserved in the lower case variant whereas the shape can be randomly alternated in the second group.

### 1.3.1.1. The criticism of Whole Shape Recognition Hypothesis

The results of recent research obtained for example with eye trackers (to be discussed in 1.2.4.) together with evidence on which other theories (elaborated on in the following sections of the paper) are based strongly oppose the bouma-based model. First and foremost, the word superiority effect cannot be accounted for in terms of the whole-word-recognition framework. McClelland and Johnston (1977) observed that pronounceability and statistical "Englishness" can determine letter identification<sup>4</sup>. This hypothesis was tested using pseudowords (non-existent words preserving phonotactic rules of a language, e.g. mave) and nonwords (non-existent words constructed against

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<sup>4</sup> Paraphrase of the following article's title: Pronounceability and Statistical "Englishness" as Determinants of Letter Identification by Jeffrey R. Travers, Donald C. Olivier (1978)

any rules e.g. amve). The researchers found that “letters are recognised faster in the context of pseudowords than in the context of nonwords” (Larson 2004)

Secondly, the evidence that words in lowercase are easier to read than those in uppercase can derive from a relatively low frequency of appearance of such font. It is claimed that if subjects had the opportunity to ‘get used’ to the uppercase typing style the results would be mirrored (Adams 1979). Furthermore, the evidence deriving from the experiment employing alternating letter case seems to be irrelevant as well. Adams (1979) demonstrated that alternating the case of both pseudowords and words yields devastating effects on their recognition, which is visible in longer response times. Thus, if case type has an impact on pseudo words the whole word hypothesis appears not to be applicable.

### **1.3.2. Feature detection**

At this point of consideration it is crucial to discuss one of the outcomes of the unquestionable development in visual word recognition research namely the Pandemonium model of letter recognition (Selfridge and Neisser 1960), as it seems to have laid the foundations of the most recent models of word recognition. According to the two researchers, there are four levels of letter recognition, the metaphorical Demons. When the sensory input is presented to the visual system, Image Demons pass it on to the second layer of the system, i.e. Feature Demons. At this point input is analysed into its constituent features which are ‘yelled out’ so that the Demons present in the next layer (cognitive) can recognise them and “shout” each time they receive information about features consonant with the letters they represent (the more matches the greater the shout). The next step, which is called the Decision Demon, involves choosing between Image Demons. It is said that the one which gives out the loudest shout (i.e. has the highest number of matching features) is selected.

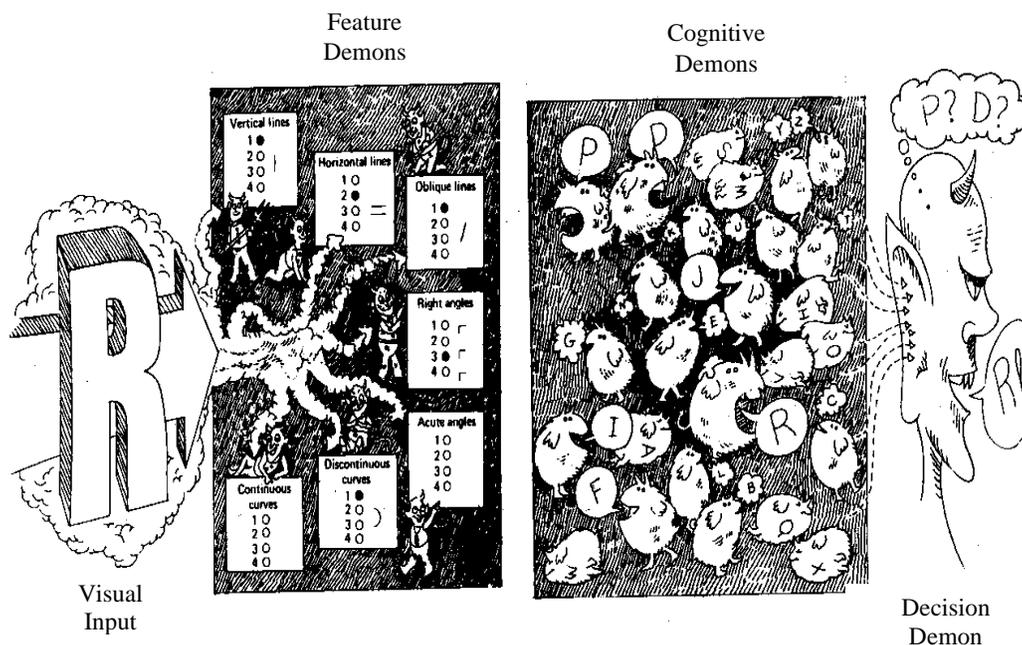


Figure 1. Pandemonium model of letter recognition (Selfridge and Neisser 1960)

### 1.3.3. Serial letter recognition as the evanescent hypothesis

Proponents of the Serial Letter Recognition model (e.g. Gough 1972) (also known as Information Processing Model) suggested that while accessing our mental lexicon we perform a letter-by-letter search. It might be quite accurately compared to a paper dictionary. In order to find a word in a reference book of this kind one has to search through it paying special attention to the sequential ordering of the constituent letters.

Gough (1972) claimed that our visual system concentrates first on each and every letter precisely analysing their features and ascribing them to proper phonemic segments and subsequently achieving connection with the meaning of a written text. He recognised several stages and processes taking place on the way to meaning retrieval, among them the “Librarian”. During this process an individual is thought to undertake a lexical search where each phonemic string is assigned the first lexical entry that can be found to match it (Katz 1998). The next stage was the mysterious “Merlin”. This layer was not specified by Gough (1972), it appears that he could not account for the process of applying semantic and syntactic rules in order to attain the understanding of a sentence as a whole (Katz 1998). The most conspicuous area, the “TPWSGWTAU” (abbreviation for ‘The Place Where Sentences Go When They Are Understood’) was

responsible for storing already understood sentences. Finally, the “Editor”, as the name might suggest, had the authority to correct any potential phonological shortcomings and made the text possible for humans to vocalise.

The evidence supporting this model is surprisingly quite substantial. First, it accounts for the phenomenon that the longer the word is the longer it takes to vocalise it. Secondly, when subjects were to state, a posteriori, whether a given word contained a certain letter or not, the amount of time given to perform this task was crucial to completing it successfully. For instance, when a subject was given 40 ms to recognise the fifth letter of a word he would be doomed to failure as 10ms is thought to be the minimal time unit for a human being to recognise a single letter. Thus, in order to reach the target letter he/she would need 50ms. This suggests that Gough’s proposal might be effective.

However, Gough’s (1972) viewpoint stands in contradiction with the word superiority effect. Reicher (1969) in his experiment proved that letter recognition is facilitated by placing them in a context, i.e. in a word. Therefore, the bottom-up recognition assumption of this theory fails to account for the phenomenon described by Reicher.

#### 1.3.4. Parallel Letter Recognition

Researchers favouring the Parallel Letter Recognition (Larson 2004) model of lexical processing claim that visual input is analysed on the basis of its constituent letters which are processed in a parallel fashion. Only when having recognised each and every constituent letter are humans able to gain access to the semantics of a given word.

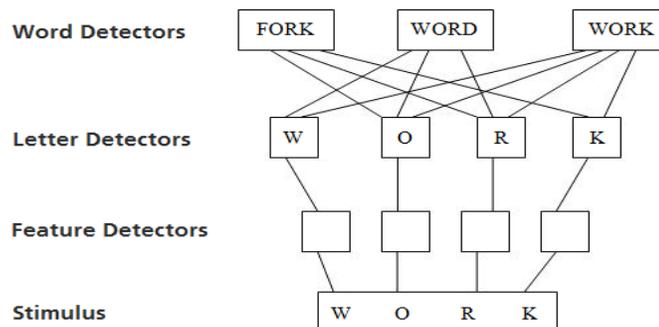


Figure 2. The Parallel Letter Recognition Model (Larson 2004)

For instance, when one attempts to read the word ‘work’ (Figure 2.), he/she needs to analyse each letter simultaneously into its constituent features, i.e. horizontal, vertical and curved lines. Immediately after that, letters whose features match those contained in the input are activated. A subsequent step involves word recognition on the basis of heretofore accessed letters. Each of the letters activates words which contain them. The word which is comprised of all of the letters receives the highest activation and is therefore recognised.

As Larson (2004) points out, the bulk of evidence favouring this hypothesis derives from eye movement research. Specifically speaking, the methods which seem to confirm this model are the *moving window study* and the *boundary study*. In the first type of experiment, researchers found that human perceptual span embraces as many as 15 letters. They arrived at such a conclusion by restricting the number of letters (i.e. putting a mask on a part of a given text) that a given subject could perceive. When the number of letters is limited to 3 past the fixation point the reading rate drastically falls to 207 words per minute (wpm). The reading rate, however, amounts to 340 wpm (i.e. is equal to when there is no mask at all) provided that 15 letters to the right of fixation point are available. Moreover, it was concluded that we do not tend to perceive letters to the left but exclusively to the right of the fixation point. Thus the moving window experiment suggests an immensely important role of sequences of single letters in the process of word recognition. However, the whole-word recognition hypothesis would predict somewhat similar reading rates, i.e. the greater the number of available letters the more of a word’s shape is revealed to the reader. This conclusion led to another eye movement experiment (the second type mentioned above) employing the mechanism of a boundary (Rayner 1975). In this type of experiment, one word in the perceptual span (15 letters) is controlled for its various aspects. In the example below (Figure 3.), when the reader reaches the word ‘put’, the element ‘ebovf’ instead of ‘chart’ appears. In normal conditions, when an individual fixates on the element ‘put’ only this particular word’s meaning is retrieved, however at the same time the subsequent letters are also available, thus facilitating later meaning retrieval. However, in this case the genuine target word ‘chart’ is available only when the saccade crosses the boundary (presented in the figure with a vertical line). In order to verify the hypothesis strings of letters of different properties (as compared to the control words) were employed, namely identical words, items of similar word shape and some letters in

common, items of dissimilar word shape some letters in common and finally items of similar shape and no letters in common. The data obtained from this experiment supports the parallel letter recognition model and contradicts the word shape hypothesis as the last type of items took participants longer to read when compared to the rest. For instance, ‘chart’ (the control word) was read in 210 ms as compared to ‘ebovf’ (similar shape and no letters in common) which took 300 ms to read.

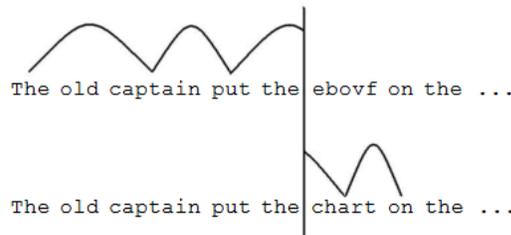


Figure 3. The boundary study (Larson 2004)

Complementing the results of this study and eliminating the word shape information Rayner (1975) changed the case of critical letters into the upper one thus giving the shape of the critical words uniformity. The results were replicated thus eliminating the ambiguity of their interpretation.

### 1.3.5. Neurology and word recognition

The most recent and widely recognised model (McClelland and Rumelhart’s Interactive Activation Model 1981) which accounts for the perception of written words has its foundations in biology. Here, researchers attempt to model human cognitive processes on the basis of mechanisms operating in our brain.

In Figure 4. below, recognition of the letter ‘T’ is depicted. The lowest layer is responsible for the processing of letter features, thus the two leftmost nodes are activated because they represent constituent features of the letter in question. The other three do not receive the activating impetus and remain inactive. Each feature node is connected to every letter. Furthermore, a letter which does not possess features compatible with a given input receives an inhibitory connection (here marked with a

circle as opposed to excitatory connections which are marked with a triangle). As a result of the highest number of active connections the letter ‘T’ is activated (analogically to the functioning of neurons in the human brain: if a neuron gets more excitatory information than inhibitory it will become active). The successive steps involve sending excitatory activation to all words starting with ‘T’. The mechanism then waits for the activation of subsequent letters in order to decide between words with the initial ‘T’.

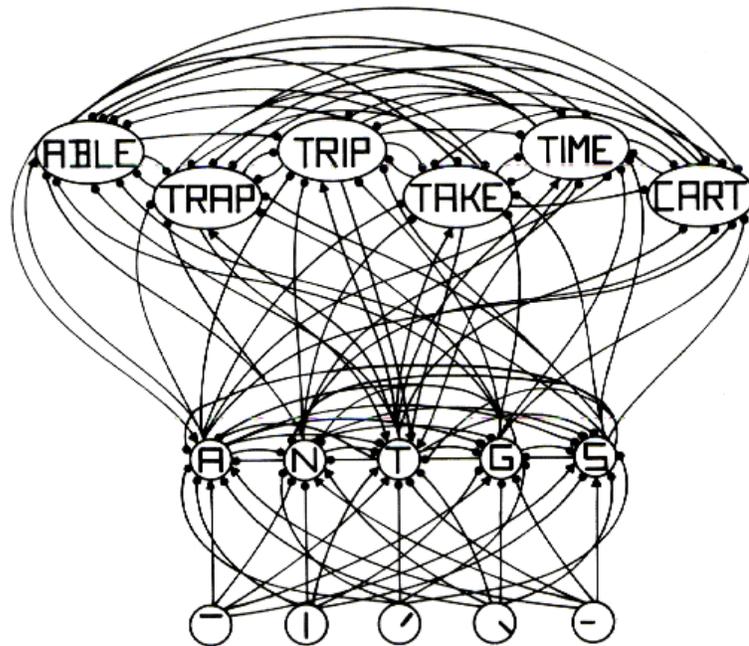


Figure 4. McClelland and Rumelhart’s Interactive Activation Model (1981)

Following Larson’s (2004) argumentation, the Interactive Activation Model is specific enough to be implemented on computers. Hence, researchers can account for e.g. the recognition of distorted pictures of words (Figure 5.).



Figure 5. Recognition of distorted pictures of words can be explained within the Interactive Activation Framework Model (Larson 2004)

According to this hypothesis, the immediate recognition of the three initial letters is thought to take place when a human is presented with the input shown in Figure 5. The subsequent step would involve deciding between the two possible options, i.e. 'WORK' or 'WORD'. The network sends an inquiry to the most bottom layer of feature detectors and because more features belonging to the letter 'K' are recognised the word 'WORK' is activated. A similar line of reasoning can be applied when accounting for the phenomenon of the word superiority effect. Thus, when a reader is presented with the three initial letters of the experimental word and the mask is put on the last one, the flow of activation is directed towards the bottom layers of letter detectors (top-down direction) giving activation to the possible graphemes. Hence, all inconsistent letters receive inhibitory status. As Balota (1994: 311) puts it: "(...) higher letter activation and inhibition overrides the delirious influence of the patterned mask".

#### **1.4. Lexical factors of analysis**

Factors belonging to this variable-level, as opposed to the lexical level of analysis, refer to the whole word rather than to its constituent parts. The most widely discussed variables in the literature belonging to the lexical type are: word frequency, familiarity and neighbourhood. They play an important role in psycholinguistic research, including the experiment presented in the paper.

##### **1.4.1. Frequency**

Word frequency has proved to have an immense effect on naming latency, gaze durations as well as (which is relevant to the experiment presented in this work) lexical decision tasks. Therefore, it appears that taking this characteristic of the word into account and trying to control for it should constitute an important demand for researchers.

Observations which say that highly frequent words are recognised faster and require shorter gaze durations led researchers to put forward questions regarding the nature of this phenomenon. In response, two major approaches have emerged in the course of the research (Balota 1994). The first one, advocated among others by Morton

(1970), is described as the activation class. It is claimed that “[h]igh frequency words, because of the increased likelihood of experience, will have higher resting activations than low-frequency words” (Balota 1994: 325). This means that in order to activate a high-frequency word, less stimulus information is needed as opposed to the low-frequency lexical items. The second class referred to as the ordered search (e.g. Forster 1976, 1979) assumes two levels of representation, namely one comprised of highly frequent materials and the other comprised of words of low frequency of occurrence. In accordance with this hypothesis, the search for the high-frequency lexical items is performed first followed by the search among those of low frequency.

### **1.4.2. Familiarity**

This variable contrary to word frequency can be considered a subjective one. Some researchers have observed that printed word frequencies are not sensitive to the mental representations of lexical items. They argued that word frequency lists are not applicable in experiments as they do not represent the spoken language<sup>5</sup> (Boles 1983). As an alternative solution they proposed subjectively rated word familiarity. Connie et al. (1990) suggested that such ratings present not only frequency in print but also frequency of production.

Such a suggestion might seem reasonable if an experiment was to be performed on a given group of people of the same occupation or with the same interests. However, it is quite doubtful that subjective reflection on word frequency can be applied to people of different language backgrounds.

### **1.4.3. The N metric**

Having noticed certain overlaps in spelling patterns within different lexical entries the word recognition researchers developed interest in how our mental mechanism selects

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<sup>5</sup> However, at present many publications concerning the spoken word frequency are available, e.g. ‘Word Frequencies in Written and Spoken English: based on the British National Corpus’ by G. Leech, P. Rayson, A. Wilson

the correct material. The experimentation began on words which are difficult to discriminate between, due to the small number of distinctive features.

The N metric, i.e. the concept of word neighbourhood, was investigated by Coltheart, Davelaar, Jonasson, and Besener (1977). It pertains to the number of words that can be created from one lexical entry by alternating only one grapheme. For instance, the aforementioned word 'WORK' has virtually one neighbour, i.e. 'WORD'<sup>6</sup>. Moreover, two factors are supposed to influence our recognition of written words, namely the neighbourhood size effect and neighbours frequency. It was observed that the neighbour size can have serious influence on response latencies in lexical decision tasks. Andrews (1989) noticed that low-frequency words with a large neighbourhood size are responded to faster as compared to those with a small number of neighbours. Words of high frequency, on the contrary, present no such interrelation. Some researchers have argued that neighbour frequency also has a substantial impact on word recognition (Grainger 1990). It is assumed that words which have neighbours of higher frequency take longer to respond to.

### **1.5. Conclusion**

This part of the paper gave a brief overview of visual word recognition science. It provides background knowledge for a specific field of psycholinguistic research - visual word recognition science. Firstly, a clear distinction was made between two types of variables, i.e. sublexical and lexical levels of analysis. Subsequently, it treated most of the prominent word recognition models in a detailed manner pinpointing their weaknesses as well as strengths. Now the discussion will proceed to a narrower branch of visual word recognition, namely the role of morphology in recognising words.

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<sup>6</sup> Actually also the word 'CORK' can be included in the list, yet as the most recent word recognition models assume left to right parsing expatiating on this particular lexical item seems unnecessary. Our visual word recognition device is assumed to immediately detect the difference between 'CORK' and 'WORK'.

## **Chapter Two: The Role of Morphology in Visual Word Recognition**

### **2.1. Introduction**

The following chapter deals with the contribution of morphology to visual word recognition. Firstly, it critically looks at some of the aspects of the literature and aims at presenting some solutions to problems encountered. Subsequently, the focus of the chapter shifts to the concept of the mental lexicon, presenting different views regarding the mental store that have emerged in the course of history. The focal point of the next subsections is the presentation of the most influential models of word recognition which concentrate on the morphology of words. Finally, it moves on to depict the model experiment.

### **2.2. Lack of terminological consistency**

Although the role of morphology in word processing has enjoyed much attention, it appears that no unanimously recognised specialist set of vocabulary has emerged. For this reason, so as to avoid any confusion of terms used in this paper, the following subchapter aims at presenting clear definitions of the concepts employed herein so as to avoid any fatal confusions of terms. However, some of the inadequacies encountered in the literature are exemplified as a starting point for the discussion.

First and foremost, the very name of this field of psycholinguistics incorporates the vague concept of the word. Balota (1994) claims that the reason why the word has been central to various psycholinguistic investigations is that “words are relatively well

defined minimal units”. However, such a view stands in opposition to basic linguistic data: “There are various ways to define a word, but no definition is entirely satisfactory” (Aronoff and Fudeman 2005; also cf. Buhler 1990). In such a case the most straightforward solution to this problem is to provide one’s definitions in a given article, however no such solution seems to be available. For example, most of the research is centred around content words and only a fraction of it is specifically devoted to function words. Moreover, it seems that no research into the domain of function words from the morphological perspective has been carried out so far. Researchers also frequently seem to misuse terms deriving from the field of morphology. Taft (1994), who could be considered to be the father of this research, refers to meaningless strings of letters (e.g. ‘hench’ from henchman, ‘peccable’ from impeccable) as ‘bound morphemes’, whereas the term itself has attained a recognisable status in morphology and enjoys quite a restrictive definition<sup>7</sup>. Similar criticism could be levelled at Butterworth (1983) when he labels the inflected forms as compounds<sup>8</sup>. However, the author equips his readers with his own definitions of linguistic concepts used throughout the paper.

It appears that the distortion of some concepts with a longstanding tradition might be due to the fact that most research is carried out by psychologists who do not want to blindly follow the blazed trails of linguistics nomenclature. Secondly, it should also be pointed out that the science of visual word recognition is somewhat young. Nonetheless, some conventions should be established in order to maintain the general intelligibility.

### **2.2.2. Definitions of basic terminology**

For the above mentioned reasons some of the terms used in this paper require a short introduction. To begin with, the very term morpheme needs a precise formulation. Following Hockett (1958:123) it can be defined as “the smallest individually meaningful element in the utterances of a language”<sup>9</sup>. Another concept which is widely used is

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<sup>7</sup> “(...)bound morphemes, i.e. morphemes which can never occur in isolation, so as to form an independent word” (Szymanek, 1998)

<sup>8</sup> This term (at least in morphology) is reserved for “a derived form resulting from the combination of two or more lexemes” (Aronoff and Fudeman, 2005).

<sup>9</sup> Additionally, following Youle, (1996) one might feel the need to add that apart from morphemes conveying meaning (free morphemes) there are such pieces of language which convey instead/also “grammatical function”.

the pseudoprefix, i.e. a bigram or trigram homographic with a prefix which, however, is not acting as such. For instance, ‘rejuvenate’ is a perfectly recognisable verb but ‘juvenate’ on its own is not. Thus, ‘re-’ in this case is an example of a pseudoprefix. A pseudostem, on the other hand, is a string of letters which is not homographic with a real stem nor can it have any meaning (Pillon 1998:95), a perfect example being ‘peccable’ or the aforementioned ‘juvenate’.

### **2.3. The Mental Lexicon**

No matter how rich one’s lexical stock is, it is not contained in a vacuum. This statement applies to each and every word a human being is in possession of. Aitchinson (1998) claims that the average educated Englishman has a repertoire of 50,000 words, i.e. vocabulary items which can be used in an ad hoc fashion. However, these are not only words which are stored in the mental lexicon: “[g]ood dictionaries give information about the meaning, pronunciation, and grammatical patterns of each word and the lexicon we carry in our heads must contain an even more detailed version of the same information” (Burling 1992: 59). Such a load of information requires special storage rules, so it sounds reasonable to refer to the question that psycholinguists have been addressing for quite a long time, i.e. how these lexical items are stored in our mind.

Unfortunately, there seems to be little common ground for psycholinguists in this respect. Various models of the mental organisation of vocabulary are postulated and no unambiguous results have been arrived at. Putting the issue into diachronic perspective, there have been two comparable views offered from the very commencement of interest in the mental lexicon.

Although this thesis is devoted to the discussion of visual perception of words, some reference to the mental lexicon is required. After all, knowledge about lexical items has to be stored somewhere in order to be retrieved in an appropriate moment. Additionally, the aim of the research is to evaluate the existing models of visual word recognition which are directly connected to the concept of the mental lexicon.

### 2.3.1. The first attempt to define the mental lexicon

The first approach to defining the lexicon states that our “mental museum” (Aitchinson 1993) is made up of the simplest forms present in a language, i.e. morphemes<sup>10</sup>. Utterances comprising of complex lexical items are then arrived at by means of rules operating on individual morphemes. This standpoint can be conceived of as a highly economical one. It suggests that we are not overburdened with remembering the whole repertoire of our vocabulary but rather arrive at appropriate complex words on the spot. However, there is no certainty that our mind wants to pursue the easiest way out requiring the minimum effort when it comes to storing vocabulary as no regular complex words would be incorporated into the lexicon according to this hypothesis.

### 2.3.2. The lexicon as a set of basic irregular forms<sup>11</sup>

Diachronically speaking, the second influential view on the ‘mental dictionary’ was advocated by Bloomfield (1933). He claimed that “the lexicon is really an appendix of the grammar, a list of basic irregularities” (Bloomfield 1933: 274). According to him the mental dictionary is merely a set of exceptions to the rules which govern language production. Complex regular vocabulary items are arrived at by the application of language-specific rules operating on morphemes. This linguistic fact is exhibited by humans on a daily basis as we are capable of producing novel complex language items which are understood by others, which is referred to as language creativity. Bloomfield (1933) refers to this ability as the *analogy* which enables the potential speaker to come up with an infinite number of morpheme combinations. Therefore, novel words entering the lexicon can be, and in most cases are, simply the result of application of the principles of language. Bloomfield also concentrates on the distinction between *regular* and *irregular* forms, claiming that the latter have to be learned in order to enter one’s lexical repertoire. Therefore they can be put into active use only when they have been previously encountered. This view has been sustained by more contemporary linguists

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<sup>10</sup> This view was formulated by a Polish linguist of the early 19<sup>th</sup> century, Jan Niecisław Ignacy Baudouin de Courtenay.

<sup>11</sup> A paraphrase of Bloomfield (1933: 274): “the lexicon is really (...) a list of basic irregularities”

who claim that “Regular variations are not matters for the lexicon, which should contain only idiosyncratic items” (Chomsky and Hale 1968: 12)

Although the approaches proposed by Jan Niecisław Ignacy Baudouin de Courtenay and Bloomfield may be thought of as strikingly similar, it must be noted that irregularities do not have to be monomorphemic regular items. Aronoff and Fudeman (2005) argue that if a language comprising only such exceptions existed it would be a perfect one. However, as far as any known natural language is concerned “we know that this position is too extreme” (Aronoff and Fudeman 2005: 53).

## **2.4. How do we store, recognise and restore words? The changing perspectives**

The aforementioned views seem to have served only as a starting point in building up a more complex hypothesis concerning the organisation of lexical items in a human mind. The questions which ought to be answered should pertain to the nature of coping with the input as it enters our memory and its organisation which, at least theoretically, has an immense influence on meaning retrieval.

The last century seems to be abundant in linguistic theories also referring to the issue of mental lexicon organisation. The most influential evolved together with the interest in behaviourism. According to the supporters of this psychological mainstream, links between stored items would be created on the basis of habit formation. Thus, when a potential subject is presented with a single stimulus he/she is assumed to perceive it as a lexical item evoking another word as a response. Results of such experiments reveal a potential pattern of connections between words. This is a brief mechanism of word association tests, naturally pushed to an extreme of simplicity. The observations obtained during this type of experiment led to the formation of the most influential models.

### **2.4.1. The atomic globule models**

One proposition accounting for lexical stock organisation can be broadly classified as the atomic globule models which are one of the most recent and influential theories. Its main assumption is that the vocabulary of any language is based on semantic primitives,

i.e. terms and concepts used to explain other terms and concepts in a language but themselves remaining inexplicable. In the framework of those models, semantic primitives are referred to as meaning atoms. Following this reasoning words which do not belong to this category have to be comprised of meaning atoms. Hence, advocates of this standpoint deduce that retrieving words which are semantically complex as opposed to semantically simple requires more time. Firstly, when perceiving a word we have to analyse its constituent atoms and only then can we retrieve its meaning. For instance, when comprehending the word 'KILL' one has to decompose it to 'cause to die', thus the response time to 'DIE' should be faster. The opposite procedure has to be applied when one wants to verbalise one's thoughts, i.e. the smallest components of a language (atoms) stored in disassembled entities have to undergo synthesis (Aitchinson 1987). However, these theoretical considerations do not seem to conform to reality as no such effects have been observed in psycholinguistic experiments. Moreover, until now no one seems to be able to prove the existence of semantic primitives and therefore most researchers abandon this view of the lexical store.

#### **2.4.2. Cobweb theories**

The second view differs significantly from its predecessor mainly in the fact that it presupposes the existence of lexical items which do not undergo the process of componental analysis. Advocates of this view treat words as wholes which have connections with other material stored in the mental lexicon.

The question that seems worth posing pertains to the strength of the connections between individual lexical items. In order to solve this puzzle, researchers resorted to word association tests; measuring thereby the strongest inter word connections. Such a method highly resembles the exploration of connections between words from the behaviouristic perspective. Researchers favouring this method of experimentation presented their subjects with a word requesting an immediate word associate. The results showed that people tend to respond with words from the same semantic field. Moreover, if words were of a 'pair-type' (e.g. husband) the most frequent responses were with their partners (e.g. wife). Finally, in the case of adults the responses tend to be of the same word class (Aitchinson 1994).

Thus, it might be stated that different people react to word association tests with different lexical items; however, linguistic typology can be applied fairly easily to classify the responses. They would go under the following headings: co-ordination, collocation, super ordination, and synonymy. From these four two seem to be the most prominent ones - as Aitchinson (1994) puts it: “within these fields, there are two types of link which seem to be particularly strong: connections between co-ordinates and collocational links”.

Probably the most important reflection on these characteristics is that the mental lexicon is not organised on the basis of formal criteria. Thus, the meaning of lexical items should not be abandoned when canvassing the structure of our mental dictionary.

#### **2.4.1. The Upside-down Tree Model**

Stating that words are organised on the basis of a certain pattern is quite a straightforward conclusion. However, arriving at the exact formula operating on the location aspect of the mental stock is a far more ambitious demand which psycholinguists have been trying to deal with for some time. Unfortunately, no unanimously accepted conclusion has been reached.

The most known and at the same time accepted hypothesis states that lexical items are hierarchically structured and grouped into layers of superordinates, i.e. concepts are hierarchically stored according to the properties they possess; the more properties can be ascribed to a word, the higher its place in the mental dictionary (Collins and Quillian 1969). For instance, the word ‘animal’ would be situated higher than the word ‘bird’ and logically the word ‘stork’ would be placed lower than ‘bird’. The data obtained in an experiment conducted by Collin and Quillian (1969) seem to confirm their hypothesis, i.e. humans seem to take longer to look up the connections between words which are not immediate neighbours in the mental network. In the experiment subjects were asked to verify sentences, e.g. ‘A canary is a canary’, ‘A canary is a bird’, and ‘A canary is an animal’. The results are presented in Table 2.

Table 2. Mean response times in the Collins and Quillan's (1969) experiment

SENTENCE	MEAN REACTION TIMES (in msec)
A canary is a canary.	1.00
A canary is a bird.	1.17
A canary is an animal.	1.23

As can be seen in the data obtained by the two researchers response times were the fastest in the first case and the slowest in the last example. It was suggested then that this is due to the rising number of branches that one has to travel through. However, other interpretations of the results were also considered, i.e. participants of this experiment might have used other strategies to determine the authenticity of the sentences, such as looking for contradictions or performing an exhaustive search. Therefore this view has met with strong opposition which has led to its redefinition. Yet, it still seems to be the most influential formulation which has contributed to the subsequent research on the organisational principles of our semantic networks.

## 2.5. Morphology in the mental lexicon and visual word recognition

The quotation of Jarvella and Meijers (1983, after Aitchinson 1998) seems to capture the still unanswered doubts: "A central question in the psychology of language is whether the mental lexicon – the dictionary in our heads – is a lexicon of words". What needs to be noticed is that apart from meaning, words also have distinctive forms. These forms can be analysed in several different ways with reference to their characteristics, e.g. their phonological form, their constituent letters and even, as was discussed in chapter one, the letter features.

As could be seen in the preceding section, even the earlier, less advanced hypotheses concerning the storage of meaningful letter strings in our minds presupposed the prominent role of morphology. The recent interest in the view which adopts the morphological perspective in visual word recognition research began with the publication of Taft and Forster (1975), who postulated the affix stripping model (elaborated on in section 2.4.2.). In response numerous 'schools' emerged including

the ones rejecting the morphological perspective on the issue in question. Although an impressive amount of research has been devoted to the problem since then, no conclusive results have been obtained so far.

Before the discussion proceeds to examine the existing models, a succinct description of different morphological types of words is required. The words ‘store’, ‘restore’ and ‘recognise’ can be considered good examples. The first one is a monomorphemic word, i.e. it consists of one morpheme only; the same morphological analysis applies to ‘recognise’. However, the analysis of this lexical item may be more troublesome as the first bigram is homographic with a prefix (thus a pseudoprefixed word). Nevertheless, it comprises only one morpheme and cannot be decomposed into more grammatically and/or semantically meaningful minimal units. The last example, ‘restore’, is a perfect instance of a polymorphemic lexical item as it can be ‘dismantled’ into {re-} + {store}.

The question which needs to be posed at this stage of consideration, and which is the main topic of the thesis, is whether the analysis presented above is represented in our mental lexicon and used during word recognition. The following subsections are meant to clarify the three major standpoints on the issue in question.

### **2.5.1. The Full Listing Hypothesis (FLH)**

One extreme view says that all of the three types of words in question are stored as ‘wholes’, i.e. the organisational rules of lexical representations (henceforth LRs<sup>12</sup>) are, so to say, blind to economical word storing accompanied by the use of morphology (Butterworth 1983, Hankamer 1989). Advocates of this position claim that the computational load accompanying online application of relevant morphological rules is greater than the ‘burden’ of storing all lexical items as wholes (Bradley 1980).

Nevertheless, proponents of this view do notice the fact that morphological rules might apply to language production as far as regular inflection is concerned. They do observe human awareness of rule application, yet it is dubious to them whether we unconsciously make any use of such knowledge. According to Butterworth (1983) rules have to be learned or deduced in order to be utilized. However, this way of handling the complex elements of lexis might prove ineffective as some rules “apply to a singleton

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<sup>12</sup> after Butterworth (1983)

set” (Butterworth 1983: 262) e.g. the suppletive forms of ‘be’. According to this line of reasoning, Butterworth (1983) claims the novel meaning of complex forms, which is achieved by the addition of derivational affixes, in many cases is idiosyncratic and therefore unpredictable. Moreover, the inefficiency of rule application pertains to the pronunciation of a myriad of words encountered in English. For this reason the only solution to such a state of affairs would be to store all the vocabulary items that a given person is in possession of separately. As far as the unpredictable semantics of words is concerned, he supports his stance with the following examples:

- (1) digest      digestion – the act of digesting
- (2) prohibit    prohibition – the act of prohibiting

In the above cases the suffix {-ion} seems to convey one and the same meaning, i.e. the act of performing a certain activity. However, the same examples prove, Butterworth (1983) argues, that the meaning of such affixes is not stable. The two forms listed below illustrate the unpredictable outcome of the same instance of derivational process, i.e. the addition of suffix {-ive}.

- (3) digestive – promoting digestion, pertaining to digestion
- (4) prohibitive – serving to prohibit (surely this derivative does not pertain to prohibiting);

Because such reasoning might be judged as a plain theoretical digression, arguments deriving from empirical experiments need to be presented. In his influential paper Butterworth makes a significant distinction as far as the modality-specific LRs are concerned (i.e. reading and speech). Here, he concentrates on distinct layers of representation possible in our mental lexicon. Analogically, one can arrange numerous experiments according to the medium imposed on the subjects, i.e. auditory tasks (concerning both speech perception and production) as well as written text perception. Each type deserves a succinct overview.

The first type of evidence in favour of FLH comes from the observation of slips of the tongue. The nature of this phenomenon in most cases, Butterworth argues, can be considered as evidence of the lack of morphological access during speech production.

The exchange of phonetic segments accompanying slips of the tongue does not strictly obey the morphemic boundaries:

(5) *heft lemisphere* vs. Target: *left hemisphere*

As can be easily noticed in these examples (Fromkin 1971) the exchanged phonemes do not constitute individual morphemes themselves although utterances in which morpheme exchange takes place have been reported, e.g.

(6) *point outed* vs. Target: *pointed out*

Yet, Garret (1975, 1980) does not accord them special significance as the amount of counterevidence seems (to him) to be overwhelming.

However, evidence which comes from aphasic patients does present a substantial portion of data which in turn is difficult to account for in the framework of FLH. In his earlier work Butterworth (1979) examines the nonsense words produced by these subjects. He arrives at the following chains of words (selected instances):

(7) he [mʌvz] in a love-beautiful home

(8) It was about in [d'zɪmərks] in ['ksɪə] neares to ['mɪʃ]

It is observed that derivational as well as inflectional affixes are attached to the nonsense stems: [z] is the contextual realisation of the plural phoneme /s/, and /ɪə / is a perfectly legitimate suffix present in English geographical names. This might suggest that instead of storing all the lexical items in the mental lexicon we might make use of regular word formation and inflectional rules. Although this explanation sounds tempting, the author stands in defence of his views and argues that the above examples derive from a conscious manipulation of the morphological knowledge, i.e. he views them as instances of fall-back procedures. Such a line of reasoning does not seem to be satisfactory as he presents no other data apart from the utterances. If the patients took no longer to utter the nonsense words than the legitimate ones Butterworth's argumentation would not be valid.

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<sup>13</sup> Symbols used after Butterworth (1983)

The evidence from experiments involving speech recognition tasks is far from conclusive as well. In Morton's (1968) experiments, in which the priming technique was employed, it was noticed that morphologically related regular forms facilitated recognition of the targets, e.g. *looking* effectively primed *looks*. What is highlighted as a tentative proof of the FLH hypothesis is that irregular forms have no priming effect on one another, i.e. for instance *stink* does not prime *stank*. Here, it appears that the author commits a linguistic mistake equating regular bound morpheme addition with vowel modification (in most cases deriving from historical processes operating on languages). The most probable explanation of the phenomena would be that recognising true morphemes is a more natural (and easier) process than even conscious grasping of the numerous paradigms of vowel alternations. The author himself remarks: "[i]t is not clear whether this change implies (...) the adoption of some kind of the FLH" (Butterworth 1983: 270).

The final modality that was subject to scrutiny is the written text, i.e. evidence from reading tasks. Butterworth (1983) argues that the interpretations of the results obtained in the experiment conducted by Murrell and Morton (1974) suggesting morphological use in lexical storage are rather dubious. The two researchers exposed their subjects to monomorphemic lexical items and subsequently measured the reaction times to their derivatives. They observed that complex forms to whose bases subjects were exposed before were recognised significantly faster. However, Butterworth (1983) argues that these effects might have been caused by the semantics of the words rather than their forms, i.e. by the semantic relatedness of given items (e.g. 'see' primes 'seen' just as 'doctor' primes 'nurse'). As counterevidence he raises the issue of LRs of idiomatic expressions. He presents the study by Swinney and Cutler (1979) who argue in favour of the 'lexicalised' status of idioms as they were judged 'sensible' faster than the matched control sentences. However, with time, as criticism of the FLH has grown a less extreme version of this theory emerged. This approach does recognise the role of morphology in storing and retrieving words from our semantic network. According to this view derivatives are listed under their 'name' which is their base (Bradley 1980). Parallel with Bradley, other researchers devised more elaborate terminology, stating that the main entry, the base form from which complex words are derived, is the 'nucleus' and the derivatives, which are linked together, are the 'satellites' of the base form (Feldman and Fowler 1987, Lukatela et al. 1988). At the same time, however, FLH advocates are aware of the fact that if the lexicon was not based on the FLH assumption,

rules operating on morphologically simple lexical items should be “stated in a lexically-sensitive way” (Butterworth, 1983), however he does not pursue this issue further. The same stance is held by Cutler and McQueen (1994: 413) who claim that “(...) morphological relations, however they may be represented, cannot be defined purely on formal linguistic grounds”.

It seems, however, that the FLH has not been tested against languages of different morphological types. English is predominantly an analytic<sup>14</sup> language, yet it would be difficult to imagine speakers of agglutinative<sup>15</sup> languages storing all the possible words in their minds. Therefore, if the FLH was to operate on the latter type of languages it would be comparable to ‘remembering’ whole sentences in English (which does not make any sense at all). Hence in an agglutinative language like Eskimo, in which a sentence can be expressed by one (‘luxuriously’ affixed) word, FLH would predict a highly uneconomical explanation of the nature of LRs. Therefore it seems that a thorough cross-linguistic study should be conducted in order to validate or nullify the assumptions of FLH.

### **2.5.2. Prelexical Mandatory Decomposition (PMD) / Affix Stripping Hypothesis**

The second extreme view is quite contrary to the one presented above since it presupposes a serious function of the morphological characteristics of the language. The very interest in the use of morphology in word recognition was triggered by the prominent paper by Taft and Forster (1975). According to the initial hypothesis, items in the central lexicon are represented in a decomposed form by their stem, i.e. with all the affixes stripped off the lexical item. The experiment carried out by those researchers involved the use of nonwords and was conducted in visual as well as auditory modalities. The conclusions Taft and Forster reached stem from the fact that subjects found it more difficult to reject nonwords composed of bound morphemes (e.g. ‘vive’ from ‘revive’) than those incorporating into their structure pseudo bound morphemes (e.g. ‘lish’ from ‘relish’). The experiment also showed that it was easier to reject nonwords without true stems as opposed to those containing a real stem (Table 3.) (e.g. *dejoue*,

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<sup>14</sup> i.e. a language in which meaningful elements are expressed predominantly separately

<sup>15</sup> i.e. languages in which morphemes of different types are concatenated; sometimes capable of expressing one sentence in one word.

dejoice respectively). These base stems, they claimed, acted as ‘access codes’ to the mental representations of words. After fierce criticism Taft reformulated his original hypothesis.

Table 3. Mean lexical decision times for real stems and pseudostems  
(Taft and Forster 1975)

	RT (msec)
<b>Real stems</b>	769
<b>Pseudo stems</b>	727

The more flexible ‘interactive-activation model’ (1994) is able to account for most of the data obtained since the first formulation of the Taft and Forster model. The main development in the theory is that it does not presuppose mandatory affix stripping, though prefixes are still treated as separate units with distinct mental representations.

What can be definitely stated is that novel words are decomposed into their constituent morphemes (if they are morphologically complex) so as to encode their meaning. Libben (1994) conducted a study employing ambiguous compounds, e.g. busheater (bus-heater/bush-eater). The results suggest that the ambiguous complex forms took participants longer to respond to than unambiguous compounds, e.g. larkeater.

Another discovery (Feldman et al. 1995) favouring the PMD suggests that when subjects were asked to shift indicated segments from, e.g. harden to the word ‘bright’ and thus arrive at brighten the task was easier to perform when the {-en} ending had a morphemic status (i.e. there was no facilitation in the case of target words like garden where the ending in question is not a bound morpheme). Thus it might indicate that morphemes, undoubtedly meaningful units, are superior to meaningless clusters of letters.

Davis and New (2004) concentrated on the morpho-orthographic properties of words. The issue they addressed is whether it is really morphemes that facilitate lexical retrieval. They adopt the distinction between the two kinds of complex words, i.e. *semantically transparent* and *opaque*. The meaning of the latter can be derived through their morpho-orthographic structure, i.e. their constituent morphemes exhibit semantic relationships with the simple forms (e.g. ‘teacher’ is a combination of {teach} and the

derivational bound morpheme {-er} which implies the performer of an action presented by the verbal stem). Semantically transparent complex words, on the contrary, refer to complex lexical items whose orthographic structure implies a false morphological relationship (e.g. 'witness' might be thought to origin from the combination of {wit} and {-ness}); these morphemes, de facto, do exist in the morphological repertoire of proficient English language speakers, however none of them was used to arrive at 'witness'). The two researchers wanted to check whether derived words prime their stems only when there is a semantic relationship (Longtin, Segui and Halle 2003; Marslen-Wilson et al. 1994, Rastle et al. 2000). Other research data implies that in the early stage of visual word recognition morphological decomposition is blind to any semantic relationships (Rastle and Davis 2003, Rastle et al. 2000). In their experiment Davis and New (2004), using a masked priming experiment, arrived at the conclusion that decomposition does actually take place in the case of complex words. Surprisingly enough, they discovered that the seemingly common morphology of words also affects target word recognition (e.g. *corn – corner*, but no *broth - brothel*).

Additionally, researchers addressed the issue of common etymology for opaque words. The stance they adopt is that shared etymology does not affect morphological segmentation (common sense suggests that most language speakers show little etymological awareness). Thus it appears that the surface structure of a given lexical item determines the way in which it will be computed in the human mind. Longtio et al. (2003) argue that our visual word recognition system decomposes any lexical material bearing a morphologically segmentable surface structure.

### **2.5.3. Augmented Addressed Morphology and Morphological Race**

Another study to be mentioned in reference to perception of written texts is the experiment conducted by Laudana et al. (1989). The model proposed by them, called the Augmented Addressed Morphology (AAM), seems to be the closest competitor to the one put forward by Taft and Forster. In the framework of this hypothesis, the lexical access device, seems to have two possibilities of arriving at a word's meaning, i.e. it can access lexical items via their full forms as well as through their constituent morphemes. The mechanism favours whole-word access as opposed to morpheme segmentation. However, the issue is far more complicated when one attempts to take into account

semantic and/or formal transparency, cohort size as well as word and stem frequency. Camarazza (1997) pinpoints that e.g. lexical items of low-frequency incorporating high-frequency stems have to undergo morphological decomposition in order to be comprehended.

As far as the study is concerned, Laudanna et al. (1989), conducted a stem homograph priming experiment, and showed that morphologically related stems did facilitate response times to target words in contrast to the case when words did not share a common morphological structure. For instance, researchers have observed a facilitation of target word recognition in cases where the stimuli shared a common stem (e.g. *portare* ‘to carry’ and *porte* ‘doors’ and they have a stem in common which is *port-*). However, no such effect was detected in pairs of words with homographic ‘stems’ which do not exhibit any morphological relation (e.g. *collo* ‘neck’ and *colpo* ‘blow’)

Together with Camarazza (1997) they have argued for the validity of their model by strengthening its foundations. In their two experiments (naming and lexical decision) they seem to have proved that there may be evidence for the existence of compositional models of lexical knowledge. In brief, they found that morphologically decomposable pseudowords were responded to faster than their orthographically matched non-decomposable counterparts, therefore it appears that no non-compositional model of lexical processing is capable of accommodating the results of these experiments.

The remaining alternative bears an original name of Morphological Race (abb. MR) (Frauenfelder and Schreuder 1992). It is also classified as a compositional model and seems to be most similar to the AAM hypothesis. However, the main difference is that the outcome of the competition between the access via morphological constituents and whole-word is not set a priori. Rather, it largely depends on the properties of an individual word such as surface frequency and semantic transparency. In short, this model assumes that words can be accessed through two independent routes which “start simultaneously and race in parallel” (Pillon 1998: 88).

#### **2.5.4. Addressing compounds**

Although much psycholinguistic investigation has been conducted in reference to morphologically complex forms little attention seems to have been devoted to the issue

of compounds. These structures have enjoyed an impressive amount of investigation as far as their linguistic description is considered. However, careful examination of mental representations and processing of compounds seems appealing as it is thought to shed new light on the issue of LRs of morphologically complex forms. Because of the fact that the meaning of some compounds is unpredictable from their constituent elements it might be tempting to equate the status of their mental representations with idiomatic expressions. However, as opposed to the majority of idioms, the semantics of some compound structures can be inferred on the basis of the analysis of their constituent parts. Therefore, two views on their LRs are taken into account, namely the Full Listing Hypothesis and the compositional model (a less restrictive derivative of PMD which presupposes morphological analysis during meaning retrieval).

For some researchers, the mental representations of compounds are thought to be stored in a decomposed way. Some claim that even the opaque compounds (i.e. complex forms whose meaning cannot be inferred on the basis of their constituent morphemes) undergo morphological analysis (Badecker 2001). If such a point of view is valid at least three stages are involved in the retrieval process of the internal structure of a compound. The first step consists of retrieving/constructing a structural representation, e.g. deciding whether it is a  $[N N_1 N_2]$  or  $[N N V]$ . Secondly, the reception of the proper lexical forms corresponding to each of the compound parts occurs. Finally, the process of linking the retrieved lexical structures with specific structural positions detected in step one takes place (Badecker 2001). This complex retrieval does not operate on monomorphemic lexical items as is depicted in the Figure 6 below.

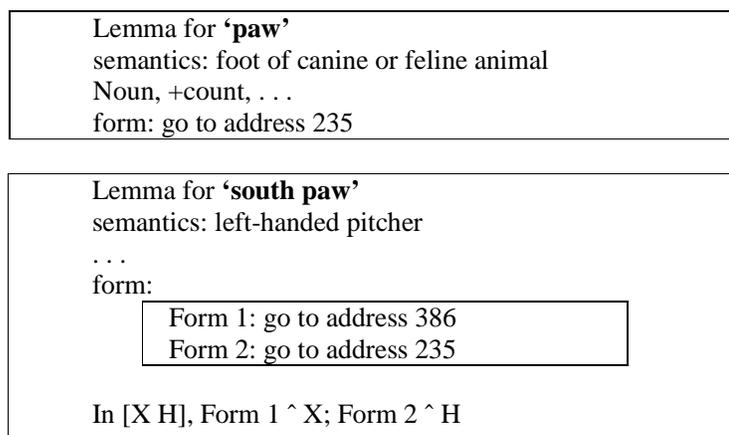


Figure 6. Example lemmas for mono-morphemic words and compounds on the compositional account of compound production (Badecker 2001)

Badecker confirms his stance with various examples from speech production as well as perception. Moreover, he conducted a case study on a subject with lexical impairment manifested in language production as well as reception. On the basis of the obtained results Badecker (2001: 337) claims that “the lexical production system takes a compositional approach to processing morphologically complex forms in the cases of productive word formation even if the semantics of the word cannot be derived formally from the meaning of its constituents”.

The opposite point of view is represented by Henderson (1985). This researcher claims that the semantic unpredictability of compounds from their constituent parts disallows their storage in a decomposed way. Additionally, she stresses the fact that various rules determine the final form of the compound and its most prominent part. Badecker (2001) also notices the possibility of a whole-word model existence, however, he pinpoints its inability to account for slips of the tongue (humans tend to swap compound constituents). Therefore, such mistakes might stand in favour of compositional models. However, data obtained by Cieslicka (2004) seems to support the FLH. She devised a word fragment completion experiment in which forty Polish native speakers were presented with a prime and then were asked to complete the missing word which was a compound. She employed three types of primes, i.e. relating to the overall meaning of the complex form, initial and nuclear stems as well as control stimuli. Primes of the first type elicited the highest number of correct responses and thus were the most efficient. These results led the researcher to conclude that “(...)the internal structure of morphologically complex words becomes available in the course of their processing by language users(...)” (Cieślicka 2004: 238-239) and therefore support the FLH.

As can be seen there is evidence supporting both extreme approaches (FLH and compositional models). Unfortunately, not enough research has been carried out into the domain of compound LRs, and therefore no conclusive remarks can be made.

## **2.6. The Model Experiment**

The experiment conducted by Pillon (1998) proves that lexical items have to undergo mandatory affix stripping. To arrive at such conclusions the researcher conducted three

experiments in French concerning prefixed words and their mental representations. On the basis of the obtained results she claims that morphological decomposition is indeed sublexical and can be attributed neither to the orthography of chosen words nor to any sort of adopted strategy.

In her first experiment, the researcher attempts to investigate the time cost of pseudofixation. It seems logical that if one strips each and every base from affixes, words of complex forms will take more time to be recognised than those of simple forms. For instance, 'reactor' is analysed into {re-} plus {act} and {-or} as opposed to 'king' which resists segmentation because of its indivisible morphological structure. Thus, the hypothesis is that subjects should take longer to recognise the items belonging to the former set.

To prove her stance she constructed 36 experimental stimuli, half of which were pseudoprefixed and half were controls. The pseudoprefixed items had to fulfil the following criteria:

- 1) start with a bigram homographic with a true prefix
- 2) comprise a pseudostem

Pseudostems in turn met the requirements:

- 1) no meaning
- 2) not homographic with any real stem

Additionally, they could not appear in any other prefixed or pseudoprefixed word. All of the items from the two sets were matched as far as the lemma frequency syllable and letter length was concerned.

Two groups of filler items were constructed. The first consisted of 110 monomorphemic lexical items of different frequencies as well as various letter and syllable lengths and was supposed to create environment inhibiting morphological 'dismantling'. The second aimed at creating conditions facilitating the segmentation. It was composed of 110 polymorphemic filler words of different frequencies, letter and syllable lengths. In order to control for the desired order of appearance, additional 16 items were constructed for each of the two lists.

There were seventy subjects participating in the experiment. All of them were native French speakers. They were asked whether what appeared on the screen was a word or a non-existent word by pressing buttons marked as ‘oui’ (yes) and ‘non’ (no). The first string of letters appeared on the monitor after a display of a fixation point of 500msec (with a warning tone). There was no limit as to the reaction time, however, if a participant took more than 1800msec a message ‘Plus vite’ (faster) appeared. Additionally, there was feedback when the decision was wrong (‘Errone’ meaning ‘error’).

The results (Table 4.) indicate that there was a substantial delay as far as responses concerning pseudoprefixed words are concerned. Such an effect was observed both in the condition facilitating and inhibiting the morphological segmentation. However, an interesting trend was observed, namely when the pseudoprefixed words were placed amid a greater number of prefixed items the response times tended to slow down. Thus, it turned out to be an insignificant phenomenon.

Table 4. Mean response times in msec for pseudoprefixed and control words (Pillon 1998)

	<b>Non Prefixed list</b>	<b>Prefixed List</b>	<b>Mean</b>
Pseudoprefixed words	823	861	842
<b>Control words</b>	781	783	782
<b>Mean</b>	802	822	812
Pseudoprefixation effect	+42	+78	+60

## 2.7. Conclusion

This chapter focused exclusively on two main issues. Firstly, on the idea of the mental lexicon and secondly, on the theories accounting for the representation of morphological structures in the lexical stock. Three main views on the topic were presented, namely the Full Listing Hypothesis, Prelexical Morphological Decomposition, and Augmented Addressed Morphology. However, as was pointed out, none of the dominating hypotheses has been unanimously approved so far. For this reason further research in this domain is required. Such research should even more

intensely concentrate on eliminating any plausible methodological confoundings so as to be helpful in defining the actual system responsible for visual word recognition.

## **Chapter Three: The Experiment**

### **3.1. Introduction**

The main focus of the present chapter is to detail the experiment conducted in order to verify the pseudoprefixation hypothesis. In the first sections special attention is devoted to the detailed description of the experiment carried out while the following sections concentrate on the obtained results and their plausible interpretation.

### **3.2. The aim of the experiment**

The goal of the experiment was to verify whether the phenomenon of the pseudoprefixation effect, proposed and verified by Pillon (1998), can be observed in native speakers of Polish whose L2 is English. Bearing in mind that the two lists were constructed (prefixed and non-prefixed), the prediction, following Pillon (1998), was that irrespective of the environment in which the experimental and control stimuli are embedded (facilitating or inhibiting) the pseudoprefixed words will take more time to be responded to. Thus, the extended version of the hypothesis might say that morphological decomposition is obligatory for almost all morphologically complex words while their meaning retrieval takes place.

### **3.3. Method**

#### **3.3.1. Participants**

Forty students of the School of English at Adam Mickiewicz University in Poznan, Poland volunteered to participate in the experiment. All of them were native Polish speakers and either 2<sup>nd</sup> or 3<sup>rd</sup> year B.A. students whose L2, which is English, is considered to be nearly native-like.

#### **3.3.2. Stimuli**

Three sets of stimuli were created. Namely, the experimental stimuli, control elements and finally, the filler items group.

Thirty experimental stimuli were constructed for the purpose of the experiment (Appendix A, B). Furthermore, they were divided into two groups on the basis of their orthography. The first group of fifteen words had ‘re-’ as their initial graphemes, the second started with ‘de-’. However, the two clusters of graphemes did not constitute true prefixes and thus are instances of pseudoprefixes. The remaining parts of the lexical items are referred to as pseudostems (section 2.1.2).

The next set of stimuli, i.e. the control group, comprised true monomorphemic words containing no prefix, pseudoprefix or pseudostem (Appendix A, B). Their number was equal to the number of experimental stimuli as members of both types of stimuli were matched with each other. Three criteria were taken into consideration when constructing the control stimuli: lemma frequency<sup>16</sup>, syllable length and letter length; these parameters of control elements were close approximations of those characterising the former group. The lemma frequency of the stimuli was taken from "Word Frequencies in Written and Spoken English" as well as from the Celex database because the first source did not contain all the lexical items needed for the experiment. The average frequency for the experimental stimuli was 4,4 and 3,86 for control words. Moreover, all of the words were between 6 and 10 letters long (only one word was 10 letters long). As far as the syllable length is concerned, the words were built up of 2 to 4

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<sup>16</sup> The summed frequency of all inflectional variants of a word

syllables (only one word was 4 syllables long). The averages being: for letter length 7,66 for experimental words and 7,66 for control words; for syllable length 2,63 for experimental stimuli and 2,7 for the control set. Most of the lexical items were nouns (out of 60 stimuli there were 12 verbs and 3 adjectives). Additionally, following Pillon (1998) the controls underwent selection on the basis of their phonological structure. In most cases the C-V-C structure was preserved<sup>17</sup>.

The sixty stimuli (the summed number of experimental and control items) were embedded into two lists of filler elements – a prefixed and a nonprefixed one. Fifty prefixed filler elements were composed of a stem and a true prefix, however they were not homographic with those contained in the experimental stimuli list. These were words of different lengths, syntactic categories and frequencies. Additionally, 80 nonwords entered this set<sup>18</sup>. Therefore, the set of filler stimuli comprised as many as 130 items (Appendix C). As far as the second list is concerned, 50 words also belonged to the list; however they had to comply with different requirements. Namely, they could not be prefixed nor start with a prefix-like bigram and had to be monomorphemic. Analogously to the first list, all words belonging to this group were of different frequencies, syllable and letter lengths and belonged to various word classes. The same number of nonwords, as in the previous set, entered the list (Appendix D).

The construction of the lists discussed above was necessitated by the presence of two conditions in the experiment. One of them was expected to facilitate the morphological dismantling and the second one, on the contrary, was thought to facilitate the analysis into constituent morphemes, hence their names: prefixed and nonprefixed respectively. Each of them consisted of 160 elements.

Altogether, there were 130 filler items in each of the two conditions. Hence, each experimental session was built up of 190 stimuli (together with the experimental and control words).

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<sup>17</sup> In two cases items from the control set had a diphthong instead of a normal vowel and in one case (decorum – crucify) the C-V-C structure was not preserved due to the problems with finding an ideal match – it seemed more reasonable to give priority to such aspects as the lemma frequency, syllable and letter length

<sup>18</sup> Nonwords were created by swapping the places of nonadjacent consonants belonging to different syllables

### **3.3.2. Procedure**

#### **3.3.2.1. Equipment**

The computer on which the program was implemented was of a portable type. The monitor was placed on the level of an individual participant's eyesight. Furthermore, the left/right shift buttons were appropriately marked with stickers saying 'YES' and 'NO' so as to avoid any potential confusion.

#### **3.3.2.2. Sequence of stimulus presentation**

A fixation point in the form of a black square was displayed for 500 msec before each letter string (the first item seen on the computer screen was the fixation point). There was also an interval of the same duration between the fixation point and the stimuli. The participants were presented with the stimuli for a maximum of 1 sec<sup>19</sup> – after this time either the decision was taken or a red square appeared on the screen, which meant that the participant had not answered during this period of time and should speed up his/her further decisions. If no response was given there was no possibility to make up for the missed item. Another interval of 500 msec followed after the lexical decision was made. Moreover, there was no feedback as to the correctness of the answer. It might seem that there was a large time pressure on the participants to react to stimuli. However, such a solution appeared the most suitable for the present study as it minimised the strategy effect<sup>20</sup>.

Prior to the proper experimental session each subject participated in a practice trial containing 10 stimuli (half words and half nonwords) (Appendix E). After completing this block it was made sure that they understood the procedure and had no doubts about it. After this trial the proper session began.

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<sup>19</sup> This is the result of adopting the speed-accuracy trade off which means that the possibility of adopting a participant-specific strategy was ruled out by imposing a time limit of one second on participants; for instance one type of subject might prefer speed over accuracy and vice versa. As a direct consequence of employing such a technique a relatively higher error rate was expected.

<sup>20</sup> Speed-accuracy trade-off research shows that the more time the participant has to solve a problem the more strategic his/her way of dealing with a problem is, as opposed to the situation in which a time limit is imposed on the participants – in such cases there is literally too little time to adopt any kind of strategy (McElree: 2006)

The stimuli were displayed in a randomised fashion and in lowercase (black font on a white background). Deciding between upper and lower case turned out to cause some difficulties. Although, there is still an ongoing debate concerning the word shape<sup>21</sup> influence on meaning retrieval some researchers seem to have proved that the predictions made by the word shape hypothesis (hereafter WSH) (section 1.2.1.) are contrary to the results of some research. For instance, "[b]oth Mayall and Humphries (1996, Experiment 1) and Perea and Rosa (2002) found that high frequency words were unaffected by case, in contrast to low frequency words" (Beech and Mayall, 2005: 302). It might be argued that the WSH would predict the opposite outcome, i.e. these would be mainly high frequency words affected by the case alternation as opposed to low frequency words. Despite all the controversies accompanying the issue, lowercase seemed the most natural and thus fulfilled the requirement of ecological validity.

### **3.3.2.3. Instructions**

The experiment was conducted in a special laboratory which was soundproof. Subjects were asked to decide whether a given string of letters is a word or not by pressing the left shift button or the right shift button. The YES/NO function of the two shift buttons was balanced across participants (half responded 'yes' with the left button, and half with the right one). They were informed that the dependent variable was the response time. Moreover, they were told that if they do not respond within one second a red square will appear on the monitor which would mean that subsequent decisions had to be faster. After the trial session the subject was left alone in the room for the experimental session.

## **3.5. Results**

### **3.5.1. Reaction times**

The mean response times for both the prefixed and nonprefixed condition are presented in Table 5 below. The response times were taken into consideration only in the cases

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<sup>21</sup> At least saying that the word shape facilitates the lexical material recognition

when the decisions were correct (sample results from a randomly chosen session can be found in Appendix E). Generally, subjects took more time to respond to stimuli in the prefixed condition as compared to the nonprefixed condition. The pseudoprefixation effect can be observed only in the prefixed condition where reaction time to experimental stimuli was 14 msec longer than to the control list. However, this effect did not turn out to be significant as  $t(19) = -1.92$ ;  $p = 0.069$ . This effect was not observed in the other condition as the experimental words were responded to 11 msec faster than the control words and again this did not reach statistical significance because  $t(19) = 1.63$ ;  $p = 0.12$ . Also,  $2(\text{Control vs. Experimental Word}) \times 2(\text{Prefixed vs. Non-prefixed condition})$  between subject ANOVA revealed no significant interaction between the type word and type of condition  $F(1,76) = 0.81$ ;  $p = 0.371$ . Moreover, the difference between the mean reaction times to control and to experimental stimuli also failed to reveal statistical significance  $F(1,76) = 0.02$ ;  $p = 0.8879$ . Yet, what seems crucial in the observations is that the response times between the two different conditions turned out to be significant,  $F(1,76) = 0.81$ ;  $p = 0.0063$ .

Table 5. Mean reaction times

	NP condition	P condition
Experimental stimuli / pseudoprefixed words	608 msec	660 msec
Control words	619 msec	646 msec
Pseudoprefixation effect	- 11 msec	+14 msec

### 3.5.2. Error rate

As far as the analysis of error rate is considered (Table 6), the number of incorrect answers was larger in the prefixed condition (1,25 for experimental stimuli and 0,85 for the control set). This revealed statistical significance  $F(1,76) = 4.02$ ;  $p = 0.0485$ , though it was small. The results indicate that more control words than experimental stimuli were wrongly responded to (on average 1,45 and 1,05 more errors were made in the nonprefixed and prefixed conditions respectively). Moreover, the

interference between the type of word and number of errors committed turned out to be significant as well  $F(1,76)= 5.7$ ;  $p= 0.0195$ . What proved to be insignificant is the interference between the condition type and word type  $F(1,76)= 0.15$ ;  $p= 0.6996$ .

Table 6. Mean error rate

Stymuli type	NP condition	P condition
Experimental	2.05	3.3
Control	3.5	4.35

### 3.6. Discussion

The results obtained by Pillon (1998) were not replicated in the present study. It did not take subjects longer to react to pseudoprefixed words irrespective of the condition in which they were embedded. Pillon (1998) observed some instances of experimental stimuli being responded to faster than the control words. However, she tries to account for it saying that some of these words were very low-frequency ones. The results are more interesting in the light of such explanations, as the average frequency of experimental words in this experiment was 0,56 higher than in the case of the control set. Thus, one might expect them to be recognised faster, whilst such observations were not consistent across the conditions. It appears that the prefix condition did actually facilitate morphological dismantling. The mean response time for the experimental stimuli in the nonprefixed condition was 52 msec faster than in the prefixed condition. Moreover, this result revealed statistical significance. Thus, it seems that when the experimental words were embedded in lexical items composed of true prefixes, the homographic pseudoprefixes were firstly recognised as real prefixes. Following this line of reasoning, it seems that the word recognition device might have stripped these words from the pseudoprefixes and subsequently, not being able to find pseudostems in the mental lexicon, started the recognition anew, this time attempting whole word recognition. Additionally, Pillon (1998) claimed that the pseudoprefixation effect is

neither an orthographic nor a strategic effect. In the case of the present study, orthography seems to have exerted immense influence on the way words were recognised as the two initial graphemes might have contributed to the overinterpretation of the stimuli made by the recognition device. Taking into consideration that the imposed time limit of 1 sec for each answer seems too short to allow any strategy adoption, strategy cannot be used as a possible explanation.

Another possible reason for the increased use of orthography might be the language background of the subjects. It seems that the competence of the native speaker cannot be compared with the one exhibited by those learning or even acquiring language in a more formal and thus less natural environment. Hence, when one wants to retrieve the meaning of a lexical item the linear order of the letters might serve as the most convenient way of recognising a word. Therefore, in the nonprefixed condition the experimental stimuli constituted absolute minority, thus the prefix-like initial letter clusters might not even have been noticed. On the contrary, when these words were embedded in the prefixed lexical items the initial prefixes and pseudoprefixes became more visible. Moreover, in the process of teaching, foreign language learners are explicitly introduced to the word formation processes. Therefore, it might be argued that even an unconscious attempt to strip the words from the two initial graphemes was made in the prefixed condition. Such an activity might help to pave the way to the meaning of the word.

Similar results have been obtained by Henderson et. al. (1984). Using a lexical decision task they noticed that there was no difference in response latencies to pseudoprefixed lexical items as compared with the control group (monomorphemic words). In this experiment the risk of subjects adopting a strategy was excluded by employing pseudoprefixed stimuli and nonwords. Moreover, participants in this experiment tended to respond faster to experimental stimuli which is consistent with the results of the present study. Pillon (1998), for instance, pinpoints the fact that Henderson did not control for the frequency of the orthographic properties such as word class, frequency of the initial bigram, and prefix productivity. However, in the present experiment only the most frequent initial bigram constructions were used (i.e. *re-* and *de-*) thus these doubts might be considered void. The author of the model experiment claims that the most frequent and therefore the most productive prefixes are thought to have their individual representations in the mental lexicon, hence words comprising these bigrams should be more prone to morphological dismantling during lexical access.

However, such a line of reasoning does not seem to find confirmation in the results of the present study because no significant effect of mean reaction time to the experimental stimuli as compared to the control group was revealed.

### **3.7. Conclusion**

The present chapter depicted an experiment whose aim was to investigate the pseudoprefixation effect in native speakers of Polish with English as their L2. Its goal was to give a broad account of the structure of the experiment and finally to provide the obtained results. The experiment seems to indicate that the pseudoprefixation effect does not hold true at least for this group of subjects, i.e. proficient speakers of English with Polish as their L1. In this case the pseudoprefixation effect appears to be only an orthographic one.

## Conclusion

The present paper provides some insight into the way humans deal with written texts in order to retrieve their meaning. During the last century the interest in the way people decode written texts resulted in numerous studies. These experiments in turn laid foundations to various theories concerning this aspect of human behaviour. A selection of the most influential ones was treated in this small-scale study. Moreover, an empirical research was conducted in order to verify the pseudoprefixation phenomenon.

The present paper was divided into three parts. The opening chapter of the thesis delivers a succinct introduction to the domain of visual word recognition research. It discusses and critically evaluates various theoretical frameworks concerning the possible ways in which words are recognised. The focus of the second part was narrowed to the presentation of the existing models of word recognition with respect to the participation of morphology in this process.

Ultimately, an experiment was conducted in order to investigate the use of morphology in word retrieval. Surprisingly enough, the results obtained by Pillon (1998) were not replicated. It was pointed out that this outcome of the investigation might be due to the effect of orthography which imposed the need of affix stripping when the experimental stimuli were embedded in the condition facilitating this process. It was also mentioned that the subjects were not native speakers of English and thus their mental lexicon might not be shaped as the one of those with English as L1. Thus, by no means was this study to invalidate the results of the model experiment<sup>22</sup>. Nevertheless, further research in this domain of psycholinguistics is necessary as no conclusive evidence supporting a particular theoretical framework seems to have been obtained so far.

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<sup>22</sup> Pillon (1998) conducted the experiment in French on subjects with French as their L1

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